Application of Discrete Choice Models in the Analysis of Determinants of Modern Contraceptive Uses among Married Women in Oromiya Region, Ethiopia: Binary Logistic Regression in Focus

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ABSTRACT

Background: *Discrete choice models such as binary logistic models have been very successful thanks to their ability to analyze the random behavior of individuals when deciding to use contraceptive methods. That is, contraceptive use is the privileged domain of application of discrete choice models. This study intends to give awareness of using contraception since the prevalence of using modern contraceptive methods is low in the country.* **Objectives:** *This study aims at presenting a binary logistic model and explores major determinants of modern contraceptive uses among married women in the Oromiya region.* **Methods:** *Ethiopian Demographic and Health Survey (2016) data was used to fit the objectives of the study. This data is collected by Central Statistical Agency every five years at the request of the Ministry of Health. The data was managed for 1474 married women in the region and analyzed by SPSS version 20. Binary logistic regression was used for the analysis of data.* **Results:** *The result of the binary logistic model shows that age of women in 5-year groups, age at first birth, type of place of residence, ever had a terminated pregnancy, number of living children, wealth status, and religious affiliation were found to be statistically significant.* **Conclusion:** *As age at first birth increases, the odds of using modern contraception decreases. Urban women were more likely to use modern contraceptives than their rural counterparts. Women who wanted the last child were less likely to use contraception whereas the poorest women were less likely to use modern contraceptives than the richest women.*

Keywords: Discrete choice models, Binary logistic, Contraception, Married women

INTRODUCTION

Family planning is comprehensive medical or social activities that enable individuals to determine freely the number and spacing of their children. It refers to a conscious effort by a couple to limit or space the number of children they have through the use of contraceptive methods. Contraceptive methods are classified as modern or traditional methods while modern methods include female sterilization, male sterilization, the intrauterine contraceptive device, implants, injectable, the pill, male condoms, female condoms, emergency contraception, standard day's method, and lactational amenorrhea method. Methods such as rhythm, withdrawal, and folk methods are grouped as traditional [1].

Family planning is approved as an important intervention that reduces maternal and child mortality and morbidity. Promoting gender equality as well as enhancing the educational and economic empowerment of women is among the enormous benefits of family planning [2]. According to Ethiopian Demographic and Health Survey 2016 report, 36% of currently married women were using a method of family planning. According to this report, 35% were using a modern method, and 1% were using a traditional method. Among currently married women, the most popular method is injectable. Urban women are much more likely than their rural counterparts to use any method of contraception.

In Ethiopia, a previous study shows that contraceptive use was highest in the age group of 15 to 19 years while it was lowest among married women aged 40 to 44 years compared to those aged 45 to 49 years. The lowest wealth status women are less likely to use modern contraception [3]. Nearly three fourth of women of reproductive age

in the Tigray region prefer Injectable contraceptives while only twenty percent of women prefer Long-Acting and Permanent Method (LAPM). Having more than two living children, discussion with husbands, and attitude of women were significantly associated with their contraceptive preference [4]. Another study by Alemayehu, et al. revealed that the overall contraceptive prevalence rate was 41.5% in the Bale zone of the Oromiya region [5]. The injectable contraceptive was the widely used method while implants and pills respectively were moderately practiced. Spousal opposition, religious beliefs, concern, and fear of side effects, and distance of family planning service were the reason for not using contraceptive methods. Unfortunately, almost all studies conducted on contraceptives using DHS data were focusing on the country level. However, since there are variations from region to region, it deemed necessary to undertake this study in the Oromiya region. Modern contraceptive use is the privileged domain of application of discrete choice models. These discrete choice models have been very successful thanks to their ability to analyze the random behavior of individuals when deciding to use a given solution such as the use of the modern contraceptive method or to appreciate the valuation of their actions [6]. The core aims of this paper are to present discrete choice models and to explore determinants of the use of modern contraceptive methods among married women in the Oromiya region while focusing on the binary logistic model.

METHODS

Study Site and Data

This study has been conducted in Oromiya National Regional State which is geographically the largest among the ten regions and two administrative cities of the Federal Democratic Republic of Ethiopia. The data used for this study was manipulated from Ethiopian Demographic and Health Survey 2016 data. This data is collected by the Central Statistical Agency (Ethiopia) every five years at a country level at the request of the Ministry of Health [1]. A total sample of 1474 married women was included in the study. Statistical software package SPPS version 20 is used for the analysis of data.

Overview of Discrete Choice Models

Several families of discrete choice models have been developed and applied in different fields of study. For instance, probit, logit, dichotomic logit, multinomial logit, conditional logit, mixed logit, nested logit, etc., each of which is specified by the statistical distribution law that follows the error term [7-9]. They consider that the environment that shapes the individual choice behavior is random and specific to each situation. Among the discrete choice models, logistic models are the most widespread and used in many different fields of health science [6]. Indeed, married women of reproductive age group can be dichotomized as those who were using modern contraception methods and who were not using modern contraception in which we can apply binary choice models. In this regard, of discrete choice models, binary logistic regression is the most relevant model to be applied to the uses of contraception.

Specification of Binary Logistic Regression

This model describes the relationship between a dichotomous response variable and a set of continuous or discrete explanatory variables [10]. The logistic regression model has become the statistical model of choice [11]. We consider first the case where the response y_i is binary, assuming only two values that are coded as one or zero.

$$y_i = \begin{cases} 1, \textit{if the } i^{th}\textit{woman was } \text{using modern } \textit{contraceptive methods} \\ 0, \textit{if the } i^{th}\textit{woman was not } \text{using modern } \textit{contraceptive methods} \end{cases} \tag{1}$$

We view y_i as a realization of a random variable y_i (the use of modern contraceptive method) that can take the values one and zero with probabilities π_i and $1- \pi_i$, respectively.

Suppose we have $X_{n*(k+1)}$ single-level binary logistic regression data matrix with k predictor variables of modern contraceptive method and $\beta_{(k+1)*1}$ vector of coefficients, then a binary logistic which fits this condition is defined as:

$$\pi_i = \frac{\exp\{x_i^{'}\beta\}}{1+\exp\{x_i^{'}\beta\}} \tag{2}$$

While the left-hand side is in the familiar probability scale, the right-hand side is a non-linear function of the predictors.

Odds Ratio of Binary Logistic Regression: The logistic regression function can be expressed in terms of the odds ratio.

$$\frac{\pi_i}{1-\pi_i} = \exp\{x_i^{'}\beta\} \qquad (3)$$

This expression defines a multiplicative model for the odds. For instance, if we were to change the jth predictor by one unit while holding all other variables constant, we would multiply the odds by $\exp\{\beta_j\}$. Following some algebraic manipulation, the following intrinsically linear function is produced.

$$\ln\left[\frac{\pi_i}{1-\pi_i}\right] = \{x_i^{'}\beta\} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_K X_K \qquad (4)$$

Maximum Likelihood Estimation: Logistic regression uses a maximum likelihood estimation technique to estimate parameters in the model. The maximum likelihood function yields the best solution for the binary logistic model and the log-likelihood function is given in equations (5) and (6), respectively.

$$L(\beta) = \prod_{i=1}^{n}(\pi_i)^{y_i}(1-\pi_i)^{1-y_i} \qquad (5)$$

$$\ln L(\beta) = \sum_{i=1}^{n} y_i \ln(\pi_i) + (1-y_i)\ln(1-\pi_i) \qquad (6)$$

Hosmer and Lemeshow Test: The well-fitted models show non-significance on the Hosmer and Lemeshow goodness of fit test. This desirable outcome of non-significance indicates that the model prediction does not significantly differ from the observed [12].

Omnibus Test: is used to test the capability of all predictors in the model jointly to predict the response variable. A finding of the significance of the Omnibus test corresponds to concluding that there is an adequate fit of the data to the model [12].

Dependent Variables of the Study: The dependent variable is modern contraceptive uses and coded as 1 for the woman who was using the modern contraceptive method and 0 for the woman who was not using it.

Independent Variables of the Study: Based on the reviewed literature, independent variables were age in five groups, age at first birth, place of residence, wanted last-child, ever had terminated pregnancy, number of living children, women's education, wealth status, religion and women's work status.

RESULTS

Characteristics of Married Women on the Use of Contraception

The result conveyed that 142 (32.3%) of the married women who were using contraceptive methods were in the age group of 25 to 29. The result further revealed that 45 (67.2%) of married women who were using modern contraception are those residing in the urban areas while only 328 (23.3%) of those residing in the rural were using a modern contraceptive method. The proportion of women who were using contraception was 119 (29.8%) and 22 (50.0%) for those with primary and secondary school, respectively. Around 9 (69%) of married women with higher education were using contraception while only 223 (21.9%) of those women with no education were using contraception. The result showed that only 27 (10.8%) of the poorest women were using modern contraception while 87 (31.2%) of the richest were using this method (Table 1).

<div align="center">**Table 1 Socioeconomic and demographic characteristics of respondents**</div>

Variables		Use of the modern contraceptive method	
		Not using	**Using**
		n (%)	**n (%)**
Age in 5-year groups	15-19	41 (80.4)	10 (19.6)
	20-24	222 (73.8)	79 (26.2)
	25-29	298 (67.7)	142 (32.3)
	30-34	280 (77.3)	82 (22.7)
	35-39	179 (83.6)	35 (16.4)
	40-44	59 (72.8)	22 (27.2)
	45-49	22 (88.0)	3 (12.0)
Place of residence	Urban	22 (32.8)	45 (67.2)
	Rural	1079 (76.7)	328 (23.3)
Highest educational level	No education	794 (78.1)	223 (21.9)
	Primary	281 (70.2)	119 (29.8)
	Secondary	22 (50.0)	22 (50.0)
	Higher	4 (30.8)	9 (69.2)
Wealth index	Poorest	222 (89.2)	27 (10.8)
	Poorer	260 (76.5)	80 (23.5)
	Middle	215 (71.0)	88 (29.0)
	Richer	212 (70.0)	91 (30.0)
	Richest	192 (68.8)	87 (31.2)

Source: Author's computation (2020)

Presentation of Binary Logistic Model

Test of Goodness-of-Fit of the Model: Hosmer and Lemeshow's test was used to test the goodness-of-fit of the model to handle numerical problems. This test shows insignificance (p=0.155) and concludes that the model is well fitted and the model prediction does not significantly differ from the observed. The finding of the significance of the omnibus test (p=0.000) corresponds to concluding that there is an adequate fit of the data to the model. This means that at least one of the predictors is significantly related to the response variable (Table 2).

<div align="center">**Table 2 Goodness-of-fit of the model**</div>

Omnibus Test	Chi-square	df	p-value
Step	242.761	25	0
Block	242.761	25	0
Model	242.761	25	0
Hosmer and Lemshow	11.912	8	0.155

Source: Author's computation (2020)

Model Summary: The -2 Log-Likelihood statistic measures how poorly the model predicts the decisions to use a modern contraceptive method such that the smaller the statistic the better the model. The usual R^2 (in OLS) statistic cannot be exactly computed for logistic regression models, so Cox and Snell R^2, as well as Nagelkerke R^2, are computed instead (Pseudo R^2). Larger pseudo R^2 statistics indicate that more of the variation is explained by the model, to a maximum of 1 (Table 3).

Table 3 Model summary

Step	-2 Log likelihood	Cox and Snell R²	Nagelkerke R²
1	1423.650ᵃ	0.152	0.224
Source: Author's computation (2020)			

Classification Table: The classification table showed that 25.7% of married women of reproductive age who were using modern contraceptive were correctly classified whereas 95% of those who were not using modern contraceptive methods were correctly classified. About 77.4% of correct predictions of overall married women in the reproductive age group is modeled by using a binary logistic regression model. The overall percent of cases that are correctly predicted has increased from 74.7% for the null model (model without predictor) to 77.4% for the full model (model with predictors) (Table 4).

Table 4 Classification table

Observed		Predicted		
		Use of modern contraceptive		Percentage Correct
		Not using	Using	
Use of modern contraceptive	Not using	1044	57	95
	Using	277	96	25.7
Overall percentage				77.4
The cut-off value				0.5
Source: Author's computation (2020)				

Odds Ratio of Model with No Predictor: The intercept-only model is ln(odds)= -1.081. If we exponentiate both sides of this expression, we find that our predicted odds [Exp(B)]=0.339. That is, the predicted odd of using the modern contraceptive method is 0.339. Since 373 of our subjects were using the modern contraceptive method and 1101 were not using, our observed odds are 373/1101=0.339 (Table 5).

Table 5 Model with no predictor

	B	S.E.	Wald	df	p-value	Odd Ratio
Step 0 Constant	-1.081	0.06	325.17	1	0	0.339
Source: Author's computation (2020)						

Determinants of Modern Contraceptive Uses

Odds Ratio of Model with Predictors: This statistic is used to interpret significant predictor variables. A total of ten predictor variables were included in the binary logistic model and variables such as the age of women in 5-year groups, age at first birth, place of residence, even had a terminated pregnancy, several living children, wealth status, and religion were found to be statistically. The odds ratios and coefficients of logistic regression and possible statistical interpretations of the results were given here. While controlling the effect of other variables in the model, the odds of married women aged 15 to 19 years were 0.099 times less likely to use modern contraception compared to 45 to 49 years. The odds of married women aged 20 to 24 were 0.178 times less likely to use modern contraception than women aged 45 to 49 years old. As the age at a first birth increase by one unit, the odds of using modern contraception are expected to decrease by 8.9% among women. On the other hand, the odd of urban women were 3.043 times more likely to use modern contraception than their rural counterparts. Consequently, the odd of married women who wanted then the last child were 0.551 times less likely to use modern contraception than those who wanted no more children while the odd of women who wanted a child later was 0.578 times less likely than those who wanted no more children.

The result also confirmed that the odds ratio for the number of living children indicates that every unit increase in the

number of living children is associated with a 33.7% decrease in the odds of using modern contraception. The odd of married women who ever had a terminated pregnancy were 1.774 times more likely to use modern contraception than those who ever had no a terminated pregnancy.

Regarding wealth status, the odd of married women in those in the poorest wealth category were 0.375 times less likely to use modern contraception than those in the richest wealth category. Married women who follow the Orthodox religion were 3.715 times more likely to use the modern contraceptive method (Table 6).

Table 6 Coefficients and odds ratio of binary logistic regression

Variable	Coeff and Se	Wald	P	Exp(β)
Age in 5 groups (Ref. 45-49)		28.75	0.000*	
15-19	-2.31 (0.87)	7.095	0.008*	0.099
20-24	-1.72 (0.76)	5.103	0.024**	0.178
25-29	-0.85 (0.71)	1.412	0.235	0.429
30-34	-0.82 (0.69)	1.398	0.237	0.442
35-39	-0.73 (0.69)	1.118	0.29	0.483
40-44	0.30 (0.71)	0.177	0.674	1.349
Age at first birth	-0.09 (0.03)	12.558	0.000*	0.911
Place of residence (Ref. Rural)				
Urban	1.11 (0.33)	11.482	0.001	3.043
Wanted last child (Ref. Wanted no more)		6.938	0.031**	
Wanted then	-0.60 (0.23)	6.922	0.009*	0.551
Wanted later	-0.548 (0.27)	4.264	0.039**	0.578
Ever had a terminated pregnancy (Ref. No)				
Yes	0.57 (0.26)	5.059	0.024**	1.774
Number of living children	-0.41 (0.06)	44.944	0.000*	0.663
Women's Education (Ref. No education)		0.241	0.971	
Primary	0.12 (0.71)	0.023	0.879	1.114
Secondary	0.10 (0.70)	0.02	0.887	1.105
Higher	0.27 (0.74)	0.129	0.719	1.306
Wealth Status (Ref. Richest)		17.082	0.002*	
Poorest	-0.98 (0.27)	13.586	0.000*	0.375
Poorer	-0.22 (0.21)	1.079	0.299	0.804
Middle	0.02 (0.20)	0.01	0.921	1.02
Richer	-0.12 (0.20)	0.353	0.552	0.887
Religion (Ref. Other)		45.61	0.000*	
Orthodox	1.31 (0.80)	2.663	0.013**	3.715
Catholic	1.17 (0.94)	1.55	0.213	3.235
Protestant	1.03 (0.80)	1.645	0.2	2.796
Muslim	0.28 (0.80)	0.121	0.728	1.32
Traditional	-0.59 (1.31)	0.203	0.652	0.555
Women's work status (Ref. Not working)				
Working	-0.12 (0.15)	0.655	0.418	0.884
Constant	2.72 (1.56)	3.05	0.081***	15.239
N = 1474 Significance levels: (*) 1%, (**) 5%, and (***) 10%				
Source: Author's computation (2020)				

DISCUSSION

Discrete choice models specifically the binary logistic model are selected because of their explanatory power on the uses of contraception. The result from this model confirmed that as the age at first birth increases, the odds of using modern contraceptive also increases. This is because the desire to have more children increases as the age at first birth increases in the sense that married women may fear not to be out of reproductive age. Urban women were more

likely to use modern contraception than their rural counterparts. The contributors of this association may include the socioeconomic status of women in cities, easy access to family planning services, and cultural disparity compared to rural areas. This result is consistent with the study conducted in Afghanistan by Osmani, et al. [13]. Married women who wanted no more children were more likely to use a modern contraceptive method. This result is in line with Mohammed, et al. who found that women who do not desire more children were more likely to use the modern contraceptive method than those who desire another child within two years in Northern Ethiopia [14]. Another study in Iran by Asadisarvestani, et al. showed that the number of desired children had a negative effect on contraceptive use [15]. This means that if women desire to have fewer children, their tendency to use contraceptives will be higher. On the other hand, having one more number of living children increases the odds of using this method. This is because a family with a large size may be exposed to so many social and psychological problems than a family with a small size if the available resources and wealth of the family are not proportional to the size of the family. Those women who had ever terminated pregnancy were more likely to use modern contraceptive methods since the termination of pregnancy is sometimes concerned with health problems that come after abortion of unnecessary pregnancy. To overcome or resist health problems related to pregnancy, those women would be more aware of proper utilization of this method. Wealth status can be explained in so many ways since it remains an important factor of several alternatives. Richest women were more likely to use modern contraceptives than the poorest women since economic power is the source of an ability to exercise one's needs to the same extent that richest women can do. Orthodox religion followers were more likely to use a modern contraceptive method. A similar result is observed in Worku, et al. regarding the effect of wealth and religion on the uses of contraception even if the role of religion on contraceptive use is not well investigated [16]. Based on the finding of the study, discrete choice models are highly recommended to the model contraceptive method as they provide sound results. However, modern contraceptive use is still low in the Oromiya region. Therefore, household-level awareness creation and necessary training should be scheduled for the women by the health promoters.

CONCLUSION

Discrete choice models, particularly the binary logistic model is well sound to model the use of modern contraceptive method among married women of reproductive age. The result of the analysis confirmed that age of women in the 5-year group, age at first birth, place of residence, even had a terminated pregnancy, several living children, wealth status, and religion were found to be statistically significant determinants of modern contraceptive use. Accordingly, married women of age 15 to 19 were less likely to use modern contraceptive methods than married women of age 45 to 49. As at age at first birth increases, the odds of using modern contraception decreases. Married women who were residing in urban were more likely to use contraception than those who were residing in rural. Women who ever had a terminated pregnancy were more likely to use contraception than those who ever had no a terminated pregnancy. Married women who wanted the last child and those who wanted the last child later were less likely to use modern contraception than those who wanted no more children. As the number of living children increases the use of modern contraception decreases. The result further revealed Women of the poorest wealth category were less likely to use modern contraception than those of the richest wealth category. Married women who were following the Orthodox religion were more likely to use modern contraception than those who were following religion other than Catholic, Protestant, Muslim or traditional. Based on the findings of the study, the following recommendations were drawn. Firstly, discrete choice models are highly recommended to the model contraceptive method as they provide sound results. Secondly, based on Ethiopian Demographic and Health Survey 2016 data, the coverage of contraceptive use is still for the Oromiya region (around 28 percent) low. Therefore, household-level awareness creation and necessary training should be scheduled for the women by the health promoters. Lastly, the identified significant variables should get special attention from policymakers and users.

DECLARATIONS

Conflicts of Interest

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

Contribution of the Author

After managing the data, the corresponding author conducted analysis and interpretation of the data and writing up the full article.

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